LUNDS UNIVERSITET

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Goal-Side Selection of Penalty Shots in Soccer

Mauro Ramos de Jesus Pereira

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Supervisor: Geoffrey Patching

Abstract

Penalty shootouts have become paradigmatic for research on anticipatory skills and decision-making. The present study examines the dynamics of goal side selection when viewing realistic images depicting a penalty kick scenario. A sample of participants (n=40) was drawn from a population of students from Lund University. Participants viewed realistic images of a goalkeeper, soccer goal, and ball placed on penalty spot. In each image the position of goalmouth was systematically displaced as to simulate the kicker's viewpoint. Similarly, goalkeeper's position was also systematically manipulated along the goal line. The experimental task consisted of choosing which goal side to kick the ball to best score a goal. General Linear Mixed Effects Modelling (GLMM, with Bimodal distribution and Logistic link) and Linear Mixed Effects Modelling (LMM, with Gaussian distribution), were used to examine whether participants' goal-side selection was determined more by the position of the Goalkeeper or Kicker. Binary goal side selection is formulated in terms of logit probability (Logit *P*), and all reaction times are transformed to represent signed response speed (*SRS*). Logit *P* and *SRS* showed close linear correspondence, adjusted R^2 = .98, F (1, 14) = 598.10, p < .001. Difference in position of the kicker and goalkeeper had a statistically significant effect on binary goal side selection, $\chi^2(1) = 8.67$, $p < .001$, and *SRS*, $\chi^2(1) = 6.75$, $p < .01$. Similarly, the joint (average) position of the kicker and goalkeeper had a statistically significant effect on Logit *P*, $\chi^2(1) = 15.72$, $p < .001$, and *SRS*, $\chi^2(1) = 17.70$, $p < .001$. In sum, the results indicate that participants' binary goal side selection and speed of goal side selection depends on the relative positioning of the 2 soccer players, goalkeeper and kicker. Present findings add to existing empirical literature about goal-side selection of penalty shots in soccer, and relate to assessment of visual neglect in neurologically impaired individuals. Current results provide some insights into understanding the circumstances under which neurologically normal individuals err when bisecting a line when viewing realistic images.

Keywords: *Goal side selection, line bisection, general linear mixed effects modelling*

Goal-Side Selection of Penalty Shots in Soccer

Everyday life is characterised by relations between physical stimuli and corresponding psychological responses. Stimuli-response dynamics constitute an essential feature of social interaction as it enables anticipation of consequences of both own actions and those of other co-actors. This ability to accurately perceive other intentions and suitably anticipate behavioural outcomes is a characteristic of skilled interpersonal relations (Dicks, Button, & Davis, 2010; Weigelt & Memmert, 2012). The present study examines penalty shootout scenarios in which goalkeeper's position and the locations of a soccer goalmouth are jointly manipulated. It is well documented that goalkeeper displacements can implicitly (Weigelt & Memmert, 2012) or explicitly (Noël, van der Kamp, Weigelt & Memmert, 2015) bias goal-side selection by luring the kicker to select the side that appears to have a larger area. From these findings the inference is that observers are prone to implicitly or explicitly select one goal-side or the other based on their estimate of where the goalkeeper is placed relative to the goal line midpoint. On these grounds, judging goalkeeper displacements along a goal line relative to the veridical goal centre resonates with the line bisection task (Masters, van der Kamp & Jackson, 2007) in which neurological healthy participants tend to place their bisection mark slightly to the left of centre.

The present study draws inspiration from studies of line bisection within neuropsychology, specifically relating to the assessment of visual neglect (Marshall, & Halligan 1990; McIntosh, Schindler, Birchall, & Milner, 2005). When asked which segment of a bisected horizontal line is longer stroke patients suffering hemispatial neglect, as a result of a lesion to their right parietal cortex, usually choose the right over the left segment (Harvey, Milner, & Roberts, 1995). Albeit to a lesser extent, healthy participants also make systematic errors when judging the relative length of the left and right segments of transected

horizontal lines; generally erring toward an overestimation of the length of left as compared to right line segments (Bowers & Heilman, 1980; McCourt & Jewell, 1999). On this basis, given the apparent similarity between the line bisection task and goal-side selection in penalty kicking tasks, the present study adopts a widely applicable weightings analysis (Hellström, 1979, 1985; McIntosh, et al., 2005; Patching, Englund, & Hellström 2012) to examine participant's goal-side selection when viewing natural scenes of a goal and goalkeeper.

Key to the present study is the work conducted by McIntosh, et al. (2005) who proposed an end-point weighting (EPW) analysis of line bisection errors, based on regression of each participant's lateral response, in respect to a fixed point in the workspace such as body midline, upon the left and right endpoint locations of each line. Effects of line length and spatial position, including cross-over effects are captured by a simple linear equation in which the location of each endpoint (L=left, R=right) is multiplied by its appropriate weighting (W_1 and W_2, where 1 and 2 indicate the spatial position of the endpoints; i.e., left=1, right=2), the products summed and a constant (k) added. Let P equal the location of each participant's line transection in regard to body midline then $P = W_1L + W_2R + k$. The relevance of the work of McIntosh et al for the present study lies on the way in which they recorded lateral position of the response as opposed to the line bisection error per se. For instance, they found that changes in location of the left end point have less impact upon responses compared to changes to the right. In this way, their studies differed from previous studies of line bisection in two distinct ways: (a) they did not treat bisection responses as errors, or a representation of subjective midpoint, but instead coded responses as locations in peripersonal space; and (b) the independent variables of interest were peripersonal locations of left and right endpoints as opposed to spatial location and line length. In the present study, systematic manipulations of lateral positions of the goalmouth aim to simulate changes in

viewing position of the kicker, which concurs with examination of peripersonal locations by McIntosh et al. (2005), and further introduces the element of a realistic sport relevant task.

Within the context of soccer penalty shootouts, goalkeepers positioning along a goal line is analogous to a line bisection task, given the standard practice of their attempt of positioning themselves at veridical goal centre. Moreover, it has been demonstrated that goalkeepers often stand marginally to the left or right (usually between 5 to 10 cm) of the true centre (Masters, et al., 2007). It is also well-documented that goalkeepers positioning slightly off the true centre influences kickers to systematically place the ball to the goal-side with greater space (Masters, et al., 2007).

One of the most compelling studies investigating goalkeeper's displacements in penalty kick situations was carried out by Masters, et al., (2007). Masters, et al., examined the starting position of goal keepers for 200 penalty kicks during elite competitions, including European Championships, World Cups, and African Nations Cups. Their study revealed that in 96% of penalty kicks, goalkeepers were not necessarily standing in the exact middle of the goal. Instead, they were displaced by a marginal difference either to the right or left of the goal centre. These observations led Masters et al. (2007) to raise the important question as to whether or not penalty kickers were aware of the goalkeeper's displacement during the penalty shootout. They found that even though keepers are not aware of marginal displacements (6 to 10 cm) from veridical goal centre, kickers are, nonetheless, 10% more likely to direct the penalty kick to the side with greater area.

In terms of psychophysics, as used regularly in neuropsychology to model line bisection errors (cf. Marshall & Halligan, 1990), changes in observer's response are subject to their ability of detecting the presence of a given stimulus, or detecting the difference between two distinct stimuli (Stevens, 1957, Dehaene, Piazza, Pinel & Cohen, 2003). This is a key feature of Weber's Law, a prominent law of sensation. In the context of the present

study, penalty kicker's ability to detect the goalkeeper's difference in positioning relative to veridical goal centre can be described mathematically on a sensation continuum. For example, if an observer is able to just notice the difference in goalkeeper's marginal displacements between 5cm and 10cm, then the *just noticeable difference* (JND) would be 5cm. Weber's law also postulates that the smallest difference in goalkeeper's displacements at which participants show above chance discrimination will be a constant:

$$\Delta I / I = k \qquad \textbf{(1)}$$

The above fraction (known as Weber's fraction [Gescheider, 2013]) formalises Weber's observations, in which I represents background stimulus intensity, and ΔI represents the required changes in intensity so that a just noticeable difference can be detected. This produces a k value which is the constant ratio. This fraction has been applied to line bisection (Marshall & Halligan, 1990) and penalty kick tasks (Masters et al., 2007). For instance, Masters et al (2007) demonstrated that goalkeeper displacements of only 0.5% to the left or right of goal centre reliably produced above chance discrimination of the area to the left and right of the goalkeeper which remained constant regardless of the relative scaling of the goal mouth. These findings were associated with Weber's law and imply that, within the context of penalty shootouts, recognition of goal keeper's displacement is a constant ratio of the kickers viewing distance, as well as the size relationship between the goalkeeper and goal (Masters et al. 2007). In similar vein, relations between the extent of rightward errors made by neglect patients in line bisection and increased line length are well described by a linear function (Riddoch & Humphreys, 1983; Rueckert, Deravanesian, Baboorian, Lacalamita, & Repplingar, 2002).

In the present study an aim is to contribute to an understanding of relations between goal side selection and goalkeeper positioning by further manipulation of goalpost

displacements, representing the view of the goal from the kicker's positioning. In turn, this will provide further insight into how neuropsychology tasks and psychophysical models relate to penalty shot out judgements when viewing realistic images. To date, studies adopting the penalty shoot-out off-centre paradigm (see Masters et al, 2007; Weigelt & Memmert, 2012; Noël, van der Kamp & Memmert, 2015; Noël, et al., 2015b) have not simultaneously and systematically manipulated the kicker's viewing position of the goal mouth. Their assumption is that the kicker always approaches the ball in a straight line, perpendicular to the goal line, placing emphasis on goalkeeper displacements alone. Yet, in studies of line bisection, the magnitude and direction of transection errors is known to change depending on where the line to be bisected is located in peripersonal space (McIntosh, et al., 2005; McCourt & Jewell, 1999). Consequently, changes of the location of the goal mouth relative to participants' peripersonal space, to simulate changes in the viewing of the kicker, may also play a role in goal-side selection of penalty shots in soccer. Indeed, most kickers approach the ball at an angle which in turn may determine (or at least play a role) in goal side selection (Kellis et al., 2004). In the present study, experimental manipulation of the goalkeeper's position relative to the centre of the goal and goalpost displacements relative to the midline of the kicker are analysed by way of binary goal side choice probabilities and reaction times (RTs).

After Patching, et al., (2012) participant's binary goal-side selections are assessed in terms of the logit (log odds ratio) of *P*, the proportion of right over left goal-side selection responses: $P=\log_e[P/(1-P)]$, and in terms of the signed response speed (*SRS*) of their timed choices by inverting each RT by the sign of the response, where *SRS* = 1/RT for right side responses and *SRS* = -1/RT for left side responses. In this respect, the present experimental study promises to reveal which of the two types of displacements (i.e. goalkeeper displacement or goalpost displacement) is a better predictor of goal-side selection in penalty

kick tasks. The contribution of the present study lies in its ability to expand further and build upon existing literature related to perception and decision making in complex environments such as penalty kicks (Masters et al, 2007; Weigelt & Memmert, 2012; Noël, et al., 2015a, 2015b). Drawing on inspiration from weighting's analyses of line bisection task McIntosh, et al., 2005 and weighting's analysis of systematic asymmetries in assessment of paired stimulus magnitudes (Hellström, 1979; Patching et al., 2012), the present study will determine the precise extent to which systematic manipulation of the goalkeeper's position and goal post displacements influences participant's choice and speed of goal-side selection. In line with studies of line bisection, the present study also promises to reveal whether there is a tendency in goal-side selection to choose the left goal-side faster and more prevalently than the right goal side, and precisely whether this tendency is contingent upon simultaneous goalkeeper and goalmouth displacements from the midline of the participant (kicker).

Method

Participants. Forty participants recruited from Lund University's student population comprising 11 women and 29 men, aged between 21-36 (mean 29 years), took part in the experiment. All participants claimed to be right-handed. Three participants claimed to be left-footed. All participants reported normal or corrected to normal vision. None of the participants played soccer on a regular basis.

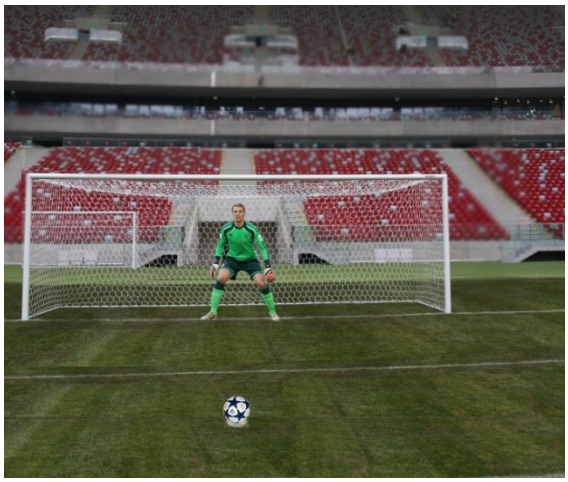
Apparatus. A microcomputer (Fujitso Lifebook Series 5) running MATLAB (The MathWorks, Inc.) was used to run the experiment. Stimulus presentation and timing were controlled using the Psychophysics Toolbox extensions (Brainard, 1997; Pelli, 1997). The pixel resolution of the video monitor was 1366 x 768 with a refresh rate of 60 Hz. Participants responded by way of two vertical arrow keys marked with red and green stickers, positioned at the bottom right of the microcomputer's standard QUERTY, keyboard. For goal

side selection, participants used the index finger of their right hand to press the down arrow key, and the forefinger of their right hand to press the upper arrow key.

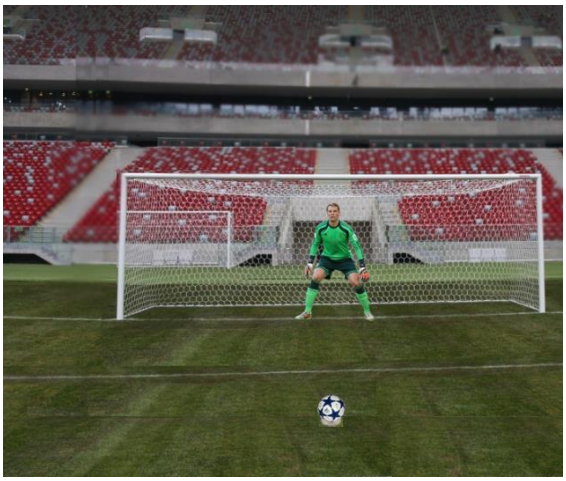
Stimuli. The stimuli consisted of 16 images (see Figure 1, for 4 example images) each representing a unique condition characterized by different combinations of goalkeeper and goalmouth displacements.

Figure 1

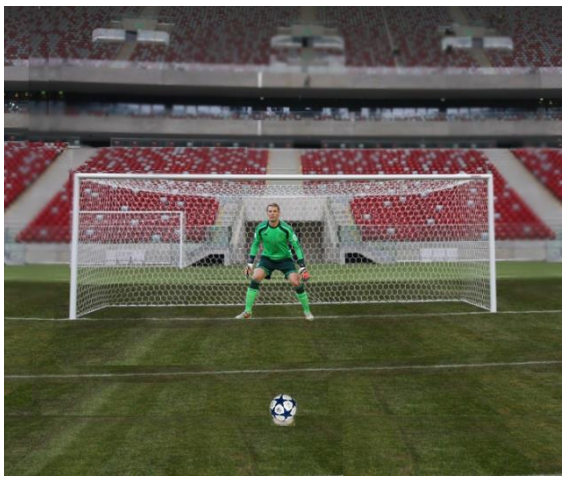
(A)



(B)



(C)



(D)

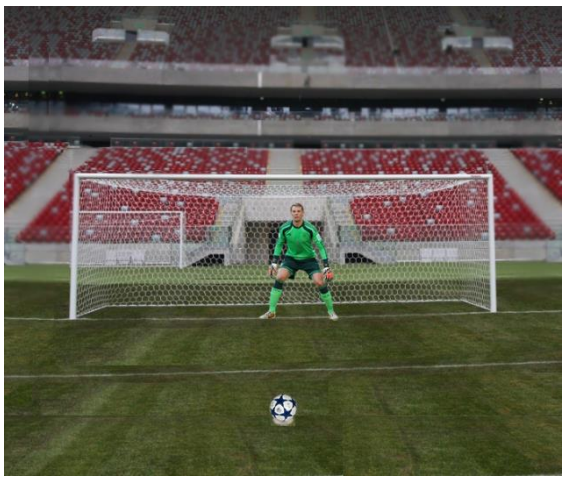


Figure 1. Example of 4 penalty shootout scenarios used in the Experiment. In all conditions, a picture of German goalkeeper Manuel Neuer was positioned on the goal line and a football was placed in the penalty spot. (A) The goal keeper is positioned centrally in the goal, and the goal mouth is offset -3.4 mm to the left of centre, so from the egocentric viewpoint of the kicker (i.e., participant, whose viewpoint was aligned with the centre of the computer monitor), they are positioned 3.4 mm to the right of the ball. (B) The goal keeper is positioned centrally in the goal, and the goal mouth is offset 3.4 mm to the right of centre, so the egocentric viewpoint of the participant is -3.4 mm to the left of the ball. (C) The goal keeper is positioned -3.4 mm to the left of the centre of the goal, and the egocentric viewpoint of the kicker is central in relation to the goal mouth. (D) The goal keeper is positioned 3.4 mm to the right of the centre of the goal, and the egocentric viewpoint of the kicker is central in relation to the goal mouth.

The goal mouth dimensions depicted in the images was 140 x 49 mm (0.0069 m^2), which is 0.04% of the total area of original sized goals used in association football [2.44 x 7.32 m (17,86 m^2)]. The goalkeeper's height was 40 mm [approximately 2% of Manuel Neuer's real height (1,93m)], and the distance between the goal line and the penalty spot (were the ball was shown) was scaled to 0,3% (0,03m) of real playing distance (11m).

The goal keeper was presented at 7 different locations relative to the centre of the goal, from -3.44 mm (left) to 3.44 mm (right) in 6 steps of 1.13 mm. In addition, the goalmouth was presented at 7 positions relative to the centre of the computer monitor, from -3.44 mm (left) to 3.44 mm (right) in 6 steps of 1.13 mm. Factorial combination of the goalkeepers positions and goalmouth displacements is shown graphically in Figure 2. Following procedures described by Hellström (1979) and Patching et al. (2012) the 7 goalkeeper and 7 goalmouth positions were combined semi-factorially about the centre of their full factorial

combination to create 16 unique images characterised by 4 physical differences between the goalkeeper and goalmouth displacements ranging from -3.14 to +3.14 mm in 4 steps of 1.13 mm (Figure 2, lower right to upper left diagonal), and mean average of the two displacements ranging from -1.70 mm to +1.70 in 4 steps of 1.13 mm (Figure 2 lower left to upper right diagonal).

Figure 2

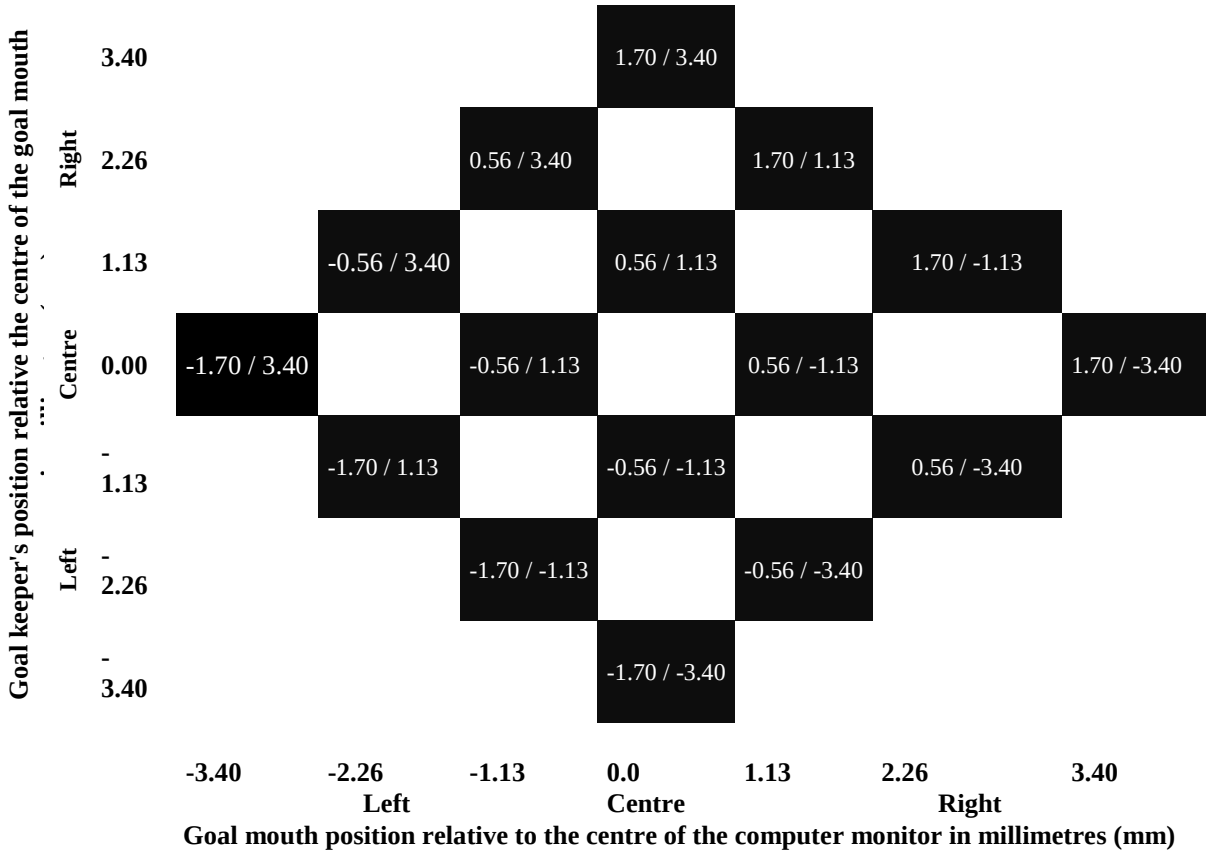


Figure 2. Semi-factorial combination of stimuli used in the Experiment. The black squares show the pairings of the goal keeper's position (relative to the centre of the goal) and goal mouth position relative to the centre of the computer monitor. The lower left to upper right diagonal shows the mean position of the goal keeper relative the centre of the goal and goal mouth relative to the centre of the computer monitor. The opposing upper left to lower right

diagonal shows the difference in the positions of the goal keeper and goal mouth. Note: there are some minor rounding errors of no concern.

Design. The experiment consisted of 2 sections (practice and experimental), with no break between the 2 sections. The first 32 trials, in which each stimulus was presented twice in pseudorandom order, were deemed practise trials. Following the practise trials, participants completed a further 256 experimental trials in which all the stimuli were presented 16 times in pseudorandomised cycles of 64 trials. The stimuli were presented in new pseudorandom orders for each participant.

Twenty participants were instructed to indicate right goal-side selection by pressing the up arrow key with the forefinger of their right hand and left goal-side selection by pressing the down arrow key with the index finger of their right hand. The other 20 participants were instructed to indicate right goal-side selection by pressing the down arrow key with the index finger of their right hand and left goal-side selection by pressing the upper arrow key with the forefinger of their right hand. Participants were seated comfortably, aligned centrally to the computer monitor at approximately arm's length (~57 cm). In this respect, the goalmouth displacements relative to the centre of the computer monitor reflect changes in the participant's egocentric viewing position of the goalmouth, hereafter referred to as egocentric viewing position or kicker's position for short.

Procedure. At the start of the experiment participants were presented with written instructions on the computer monitor. From the kicker's perspective, participants were instructed to decide, as quickly as possible, the best side of the goal (left or right) to place the ball to score a goal. Participants were required to indicate that they had understood the instructions by pressing one of the response keys to start the experimental session. On each trial, each image was presented until the participant made a goal-side selection either by

pressing the up arrow key or down arrow key. RT was measured from stimulus onset until the participant made a response. The inter-trial-interval was set at a random duration from 1000-3000ms. On average, participants took 30 minutes to complete the experiment.

The present experiment was carried out in accordance with the rules and regulations laid down by the Ethics Committee for the Swedish Research Council. All participants gave written informed consent in accordance with the Declaration of Helsinki by signing the participant information and consent form.

Data analyses. First, signed response speed (*SRS*) was calculated as 1/RT (in seconds) for right-goal side responses, and -1/RT for left-goal side responses. In addition, the relative frequency of binary choice responses to the stimuli was expressed in terms of logit *P* - the natural logarithm of the proportion of right goal side responses over the proportion of left-goal side responses: logit $P = \log_e[P / (1 - P)]$. In arriving at these values, all responses longer than 2000 ms were defined as misses (10.45% of responses) and all responses less than 200 ms were defined as premature response (0.45% of responses) and discarded from further analyses.

To examine relations between logit *P* and *SRS*, logit *P* and mean *SRS* were summarized over all participants for each of the 16 pairings of the position of the goal keeper and kicker. Relations between logit *P* and mean *SRS* were then examined using standard linear regression.

Generalized Linear Mixed Effects Modeling (GLMM, with Bimodal distribution and Logistic link) and Linear Mixed Effects Modeling (LMM, with Gaussian distribution), were used to examine whether participants' goal-side selection was determined more by the position of the Goalkeeper or Kicker. To this end, weights W_1 and W_2 were estimated by logistic regression of binary responses and separately by linear regression of *SRS*, on the standardized egocentric viewing positions of the participant, *kicker* = *Z*(kicker position), and

standardized lateral positions of the goalkeeper relative to the center of the goal, *keeper* =*Z*(goalkeeper position):

$$GS_{12} = K + W_1 kicker - W_2 keeper. \quad \textbf{(2)}$$

Here, the regression constant (*K*) estimates participants' tendency to select the left or right side of the goal - a negative effect is taken to indicate left goal side selection and a positive effect right goal side selection. The slope of the relationship between goal side selection (GS_{12}), the kicker's position ($kicker$), and goalkeeper's position ($keeper$), gives participants' weighting of the kicker's (W_1) and goalkeeper's (W_2) lateral positions in goal side selection. The lateral standardized positions of the *kicker* and *keeper* were entered as fixed effects, and participants were entered with their own intercepts as well as by-participant and by-condition random slopes for the positions of the *kicker* and *keeper*.

To examine the influence of the relative position of the *kicker* and *keeper*, GLMM (with Bimodal distribution and Logistic link) was used to regress participant's binary goal side selections, and separately *SRS* (using LMM, with Gaussian distribution), on the difference in the positions of the kicker and goalkeeper (Figure 2, upper right to lower left diagonal), and on the average position of the goalkeeper and kicker (Figure 2, upper left to lower right diagonal). Subsequently, the following equation was fit to the data

$$GS_{12} = (W_1 + W_2)(kicker - keeper)/2 + (W_1 - W_2)(kicker + keeper)/2 + K \quad \textbf{(3)}$$

Following the procedures described by Patching et al. (2012; see also McIntosh et al., 2005, for a similar approach), statistically reliable coefficients for $(kicker - keeper)/2$ indicate that a significant proportion of the variance in goal side selection (GS_{12}) can be

attributed to the defined physical differences between the egocentric viewing position of the kicker and lateral position of the goalkeeper. Most importantly, if statistically reliable coefficients obtain additionally for $(kicker + keeper)/2$ then a significant proportion of otherwise unaccounted variance can be attributed to the joint positions of the kicker and goalkeeper, which indicates that $(W_1 - W_2) \neq 0$. The average position of the *kicker* and *keeper*, and the differences in the position of the *kicker* and *keeper*, were entered as fixed effects. Participants were entered with their own intercepts as well as by-participant and by-condition random slopes for the difference $(kicker - keeper)/2$ and average $(kicker + keeper)/2$ effects respectively.

All analyses were conducted using R (R Core Team, 2017). The package lme4 (Bates Maechler Bolker, & Walker, 2015) was used for linear mixed effects modeling. Visual inspection of residual plots did not reveal any obvious deviations of homoscedasticity or normality. To assess the overall fit of each model, *p*-values were obtained by likelihood ratio tests of each model with the variable in question against the same model without the effect.

Results

Figure 3 shows the relationship between mean *SRS* and logit *P*, as fit by standard linear regression over the 16 different stimulus pairs. Logit *P* and *SRS* show close linear correspondence, adjusted $R^2 = .98$, $F\ (1, 14) = 598.10$, $p < .001$.

Figure 3

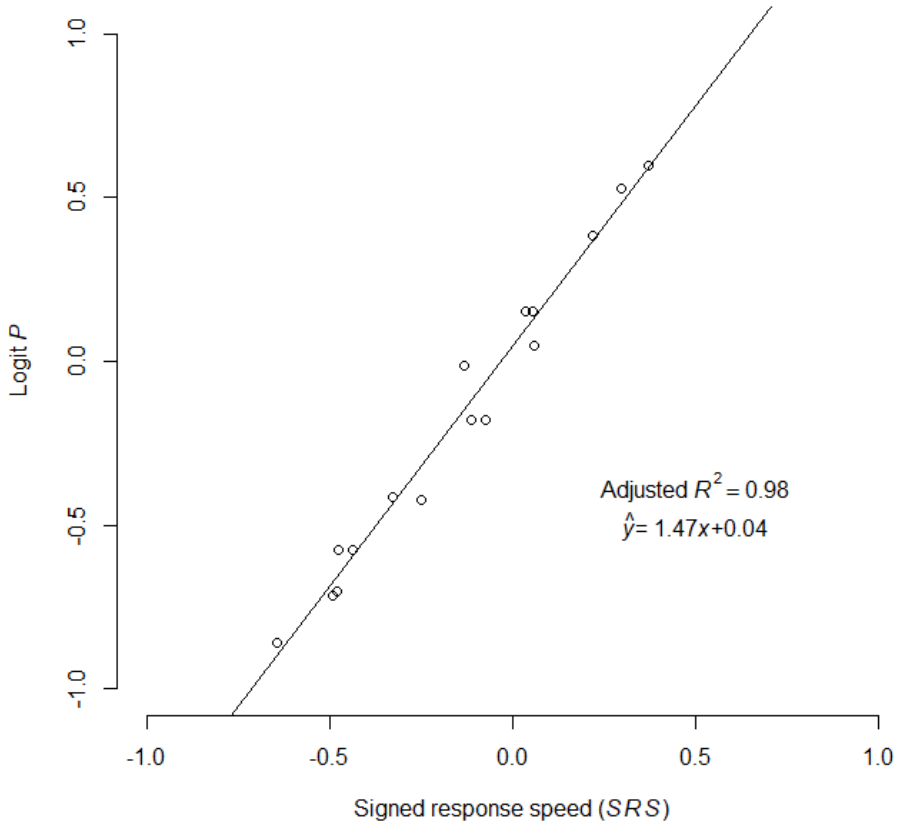


Figure 3. Relationship between Logit *P* and mean *SRS*. Logit *P* and mean *SRS* were computed over all participants.

To examine further participants' general tendency to choose the left or right goal-side and their weighting of the lateral position of the goal keeper and egocentric viewing position of the kicker, the data were then analysed in terms of Equation 1. Figure 4 shows mean logit *P* and mean *SRS* for the egocentric positions of the kicker, marginalized over the lateral positions of the goalkeeper, and separately mean logit *P* and mean *SRS* for the lateral positions of the goalkeeper, marginalized over the egocentric viewing positions of the kicker.

Figure 4

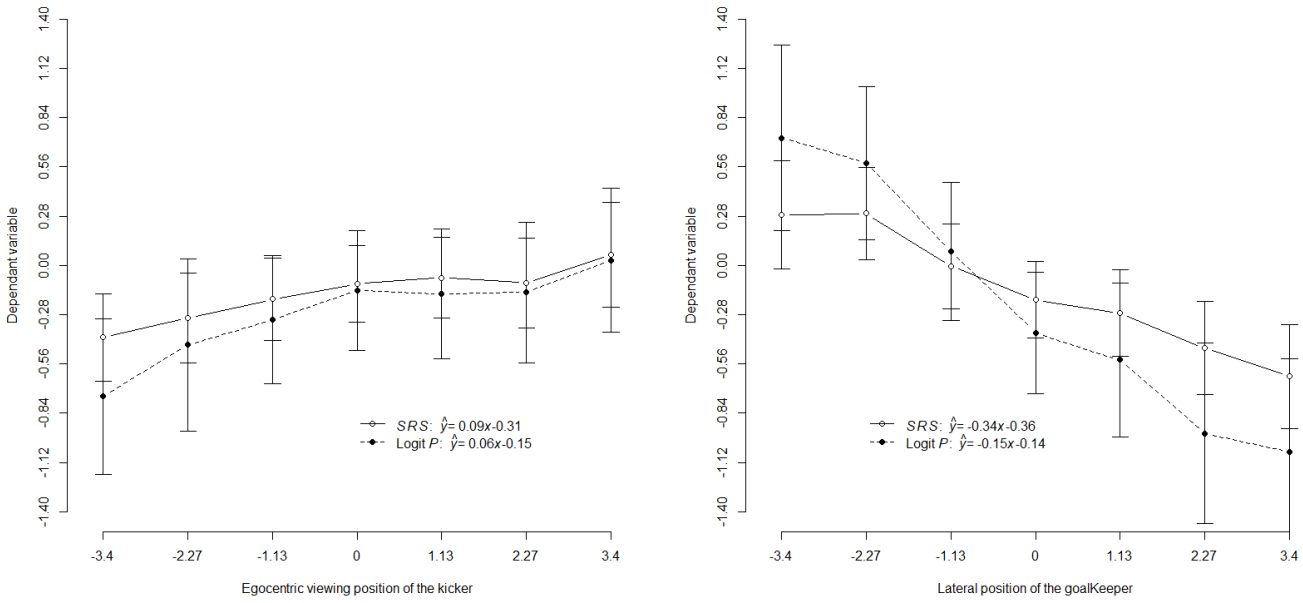


Figure 4. (A) Mean Logit *P* and mean *SRS* by the egocentric viewing positions of the Kicker marginalized over the lateral position of the Goalkeeper. (B) Mean Logit *P* and mean *SRS* by the egocentric viewing positions of the Goalkeeper marginalized over the lateral position of the Kicker. The linear equations show the unstandardized fixed effect coefficients for regression of *X* on *Y*. The error bars show 95% confidence intervals.

Subsequently, weightings differential percentages (*WD*%) were calculated for each participant by dividing the difference between the absolute (unsigned) values of the weightings, W_1 - W_2, by their mean; *WD*% = 200 (W_1 - W_2) / (W_1 + W_2). In this respect, ±*WD*% indicates participant's relative weighting of the position of the goal keeper and egocentric position of the kicker, and the relation *WD*% = 0 was tested by (two-tailed) one-sample *t* tests. The results of fitting Equation 1 to the data are shown in Table 1. No

statistically significant effects of response assignment were found (all *ps* > .05). So, response assignment is not included in the final linear models reported in the present paper.

Table 1

	Logit *P*	*SRS*
Constant (*K*)	-0.37	-0.14
Weightings (*W_1* / *W_2*)	0.17 / 0.62	0.10 / 0.26
WD%	-50.56	-57.91
p value for *WD*% ≠ 0	< .01	< .001

Table 1. Fixed effects for the constant (*K*) and absolute (unsigned) weightings (*W_1* / *W_2*), along with their weightings differential percentage (*WD*%), as determined on the basis of fitting Equation 1 to each participant's binary goal side selections and signed speed of participant's responses (*SRS*).

To examine the influence of the kicker's position and lateral position of the goalkeeper on goal side selection logit *P* and mean *SRS* were computed over trials for each of the five average position of the kicker and goalkeeper (see Figure 2, lower left to upper right diagonal) and separately for the difference in the positions of the kicker and goalkeeper (see Figure 2, lower right to upper left diagonal). These summaries of Logit *P* and *SRS* are shown graphically in Figure 5.

Figure 5

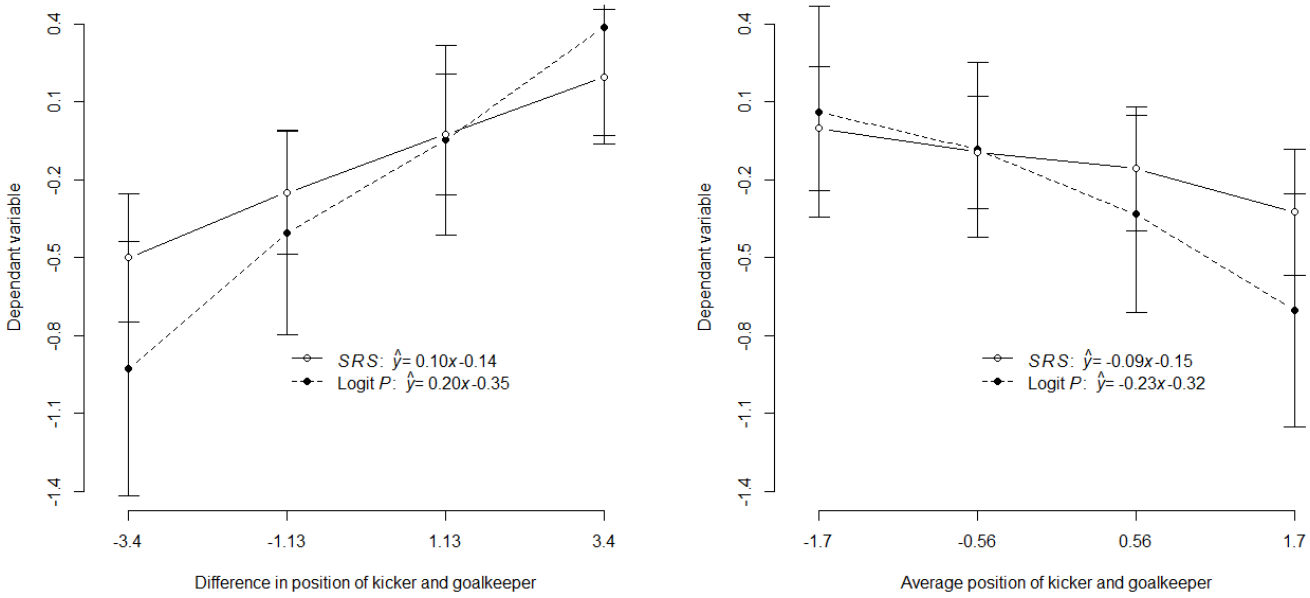


Figure 5. (A) Mean Logit *P* and mean *SRS* by the difference in the position of the goalkeeper and egocentric viewing position of the kicker (Figure 2, lower right to upper left diagonal). (B) Mean Logit *P* and mean *SRS* by the mean average position of the goalkeeper and egocentric viewing position of the kicker (Figure 2, lower left to upper right diagonal). The linear equations show the unstandardized fixed effect coefficients for regression of *X* on *Y*. The error bars show 95% confidence intervals.

Equation 2 was then fit to participants' binary goal side selections and separately to *SRS*. The difference in position of the kicker and goalkeeper had a statistically significant effect on binary goal side selection, $\chi^2(1) = 8.67$, $p < .001$, and *SRS*, $\chi^2(1) = 6.75$, $p < .01$. Likewise, the joint (average) position of the kicker and goalkeeper had a statistically significant effect on Logit *P*, $\chi^2(1) = 15.72$, $p < .001$, and *SRS*, $\chi^2(1) = 17.70$, $p < .001$. The indication is, therefore, that $(W_1 - W_2) \neq 0$, such that participants differentially weighted the egocentric viewing position of the kicker and lateral position of the goal keeper in goal side selection.

General discussion

The present experiment examined participants' binary goal-side selection and speed of goal-side selection given small changes in the lateral position of the goal keeper and egocentric viewing position of the kicker. To this end both the egocentric viewing position of the kicker and lateral position of the goalkeeper were jointly manipulated. Both the speed and binary, left or right, selection of where best to place the ball to score a goal were examined by way of Generalized Linear Mixed Effects Modelling (GLMM) and Linear Mixed Effects Modeling (LMM).

Data show a close relationship between binary goal side selection and signed speed of the selection. Therefore, it appears that both logit *P* and *SRS* are sensitive to changes in the lateral positions of the kicker and goalkeeper and can be used, equivalently, to scale goal side selection as a function of the 2 players' positioning.

In psychophysical terms, one can only perceive a difference between physical stimuli when it actually overcomes some differential (Krueger, 1989). Applying this notion to penalty kick scenarios, it is evident that the extent to which observers recognized changes in goalkeeper's position depended on the relation between goalkeeper and goalmouth displacements. Participants' goal side selection was influenced by the egocentric viewing position of the kicker and lateral position of the goalkeeper. In goal side selection participants placed greater weight on the lateral position of the keeper than on the egocentric viewing position of the kicker. This conforms to earlier research which indicates that goal side selection is influenced by the lateral position of the goalkeeper (Masters et al, 2007; Weigelt & Memmert, 2012; Noël, et al., 2015a, 2015b), and goes further by showing that goal side selection is, albeit to lesser extent, also influenced by the egocentric viewing position of the kicker. These results are also in line with studies assessing visual neglect demonstrating that

neurologically normal individuals are also prone to overestimate the length of a line segment leftwards as compared to the right (McCourt & Jewell, 1999; Jewell & McCourt, 2000).

The majority of professional soccer players are competent with both feet. However, in very specific choice-based situations such as corner kicks, free kicks, and penalty kicks they use their preferred foot (McMorris & Colenso, 1996): in real-life scenarios, penalty takers do not approach the ball in a straight-line. Biomechanical analysis of technical aspects involved in penalty kicks reveals that players often approach the ball at an angle (Kellis et al., 2004). More specifically, it is thought that an angled approach enables better contact with the ball by facilitating a greater knee and hip flexion range of motion (Lees & Nolan, 1998). Previous studies investigating the effects of goal keeper displacements on goal-side selection did not take into account angle of ball approach on penalty shootouts, as well as the fact that penalty takers do not often approach the ball at an angle of 0° (Isokawa & Lees, 1988). In this respect, Isokawa and Lees (1988) demonstrated that the optimal approach angle is between 30° and 45° with a maximum degree of kicking velocity achieved at 30° and maximum ball speed at 45°. So, the strategic introduction of goalmouth displacements in the present study constitutes a small but yet significant methodological development from previous studies by which to investigate further the role of the kicker's angular run up position on goal side selection in penalty kicking tasks. Moreover, present manipulation of the goalmouth relative to participant's body midline fits with studies of line bisection (see McIntosh et al, 2007) in which the egocentric position viewing position of participants is known to affect the magnitude and direction of line bisection errors.

Overall, the present study found a significant association between goalpost displacements and goal-side selection and these findings are consistent with empirical findings from the line bisection task (McCourt, & Olafson, 1997). More specifically, the present findings show that there is a general left-side goal selection bias. Additionally,

participants showed a tendency to choose the goal-side with a greater area relative to the goal keeper displacements. Together, these findings provide supportive evidence for the notion of an inherent implicit action priming which may trigger certain response patterns (Weigelt & Memmert, 2012; Noël, van der Kamp & Memmert, 2015).

The present experiment shows that participants' goal side selection was jointly influenced by the egocentric viewing position of the kicker and lateral position of the goalkeeper. Participant's increasingly selected the left goal side as the average position of the goalkeeper and kicker became more rightward, and participants' tendency to choose the left goal side became increasingly rightward as the position of the goalkeeper shifted leftward and the position of the kicker rightward. The indication is, therefore, that participants' binary goal side selection and speed of goal side selection depends on the relative positioning of the 2 soccer players. This further strengthens evidence from previous empirical literature, but also emphasizes the role played by the peripersonal egocentric position of participants as examined using a weighting's analysis as proposed by McIntosh et al., (2007).

In summary, the present shows that systematic leftward-oriented errors as found in line bisection studies are also present in a penalty kick task involving realistic images. This makes a strong case for the validity of such studies, specifically when considering neurologically normal individuals in their everyday surroundings. This study has also demonstrated that participants' binary goal side selection and speed of goal side selection depends on the relative positioning of the 2 soccer players (i.e. goalkeeper and kicker). Future studies should seek to examine the extent to which participants were aware of goalkeeper and goalmouth displacements. This would help determine the precise extent to which goal-side selection was implicitly or explicitly biased.

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